

ON THE SPECTROSCOPE AND ITS APPLICATIONS

III.

SO far, I have spoken of spectroscopes as spectroscopes—as one of the instruments the improvement of which should be cared for by every student in science. Their applications will come after. As may be imagined, spectroscopes are now constructed with one, two, three, four, or more prisms, the number depending on the pur-

pose for which they are to be employed. An instrument with one prism is usually called a chemical spectroscope, for an instrument of this kind is now almost as important and essential in a chemical laboratory as a balance. Spectroscopes are also constructed with two prisms, as shown in Fig. 13; these are used in cases when rather more dispersion is desired than can be obtained with the one-prism instrument. When, however, any accurate and elaborate work has to be done, such as in carrying out original investigations, more prisms have to

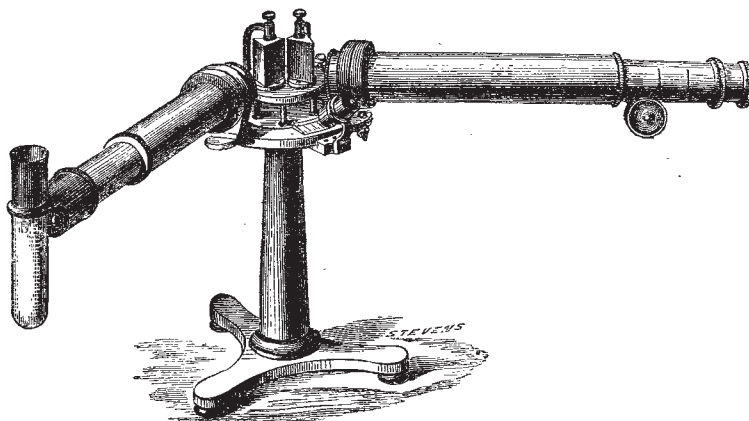


FIG. 13.—Spectroscope with two prisms.

be employed. The engraving given in Fig. 14 is of an instrument which historically is extremely interesting, as being the one with which Kirchhoff made his most elabo-

rate and accurate maps of the solar spectrum; it is furnished with a battery of four large prisms, which give an enormous deviation and dispersion. There is no reason

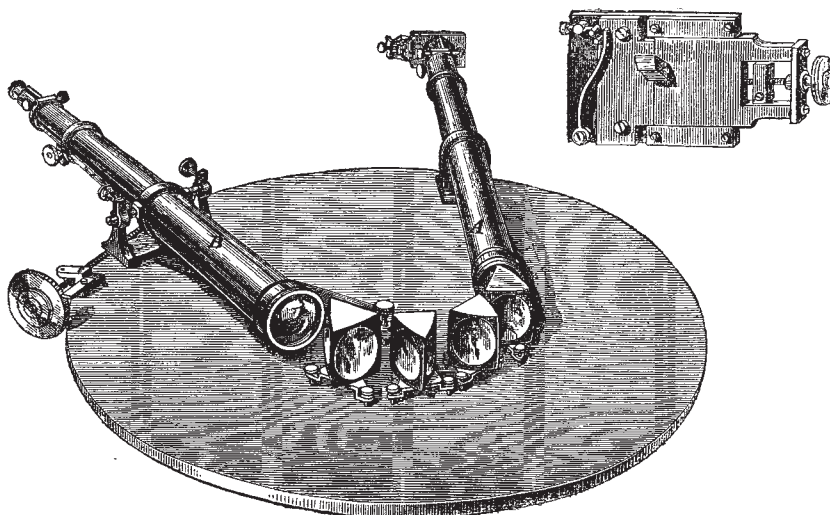


FIG. 14.—Steinheil's form of four-prism spectroscope; arrangement of slit shown separately.

why spectroscopes of many more prisms should not be employed, except that they require to be worked only with strong lights, as light is here so much dispersed or spread out that a feeble spectrum would be almost lost. As the principle of construction is almost the same in all kinds of spectroscopes, we had better commence by a description of the simplest form, namely, that with one prism, as shown in Fig. 15. It will be seen to consist of a circular table, supported by a pillar and three legs, carrying three lateral tubes; the right-hand tube is called the collimator, and holds at its outer extremity the fine

slit, the width of which can be regulated to a nicety by a micrometer screw; the other end of the collimator is furnished with a lens, which serves to collect the rays of light coming from the slit, and to render them parallel before falling on the prism in the centre of the table. The prism is so placed and fixed by a clamp that the light entering the slit from the source of light, shown in the figure as a gas lamp, strikes it and leaves it at what is called the *angle of minimum deviation*, a term which has already been explained; after passing through the prism, in which the light undergoes both deviation and dis-

persion, the spectrum is observed by the telescope on the left, which is simply a small astronomical telescope of low magnifying power. There are two methods of measuring spectra. The telescope may be attached to a

moveable arm, which can be directed to any part of the spectrum that may be required; and the outer edge of the circle along which the telescope moves may be graduated with an accurate scale of degrees, which can be divided

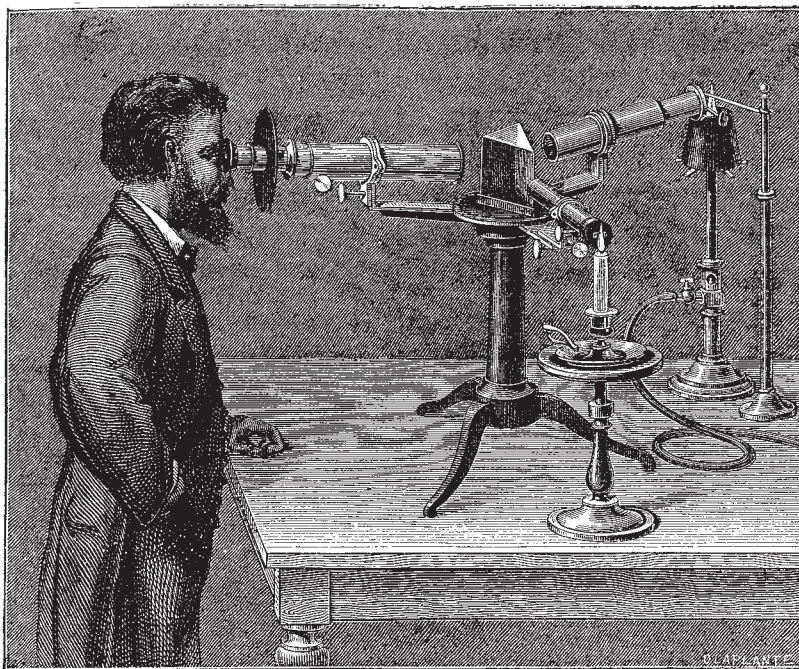


FIG. 15.—Spectroscope with reflected scale.

with more or less minuteness, according to the precision in the exact position of the dark lines, &c., in various spectra required. In this method the line to be measured is brought into the centre of the field of view of the observ-

ing telescope, and the position of the telescope read off. Of course if the line measured is situated in the red end of the spectrum, the telescope will be in a different position to that it will occupy if the line be in the blue end. The

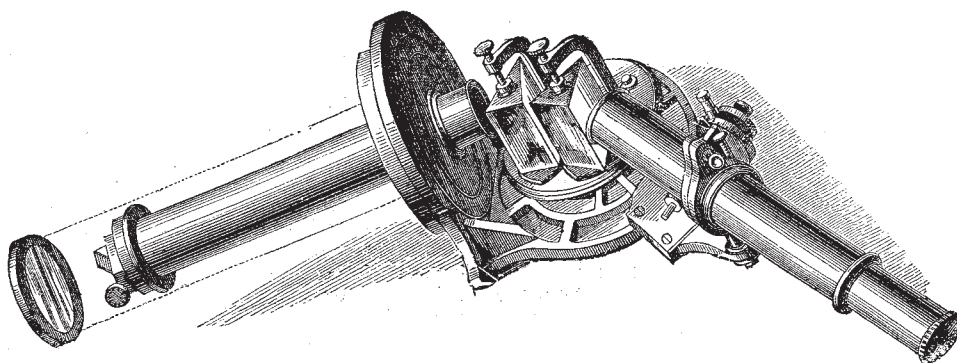


FIG. 16.—Huggins' star spectroscope.

second method of measurement may be gathered from Fig. 15. It consists of a short tube carrying at its outer extremity a small photographic scale, which is illuminated by a candle flame; the light passing from the photographic scale is rendered parallel and thrown on the surface of the prism by means of a lens in the tube carrying the scale, and is reflected by the last surface of the prism up the observing telescope, so that it is seen

as a bright scale on the background, formed by the spectrum under observation.

The spectroscope has also been adapted to the telescope with very great success; for it is essential not only to determine the spectra of the light emitted by various substances in our laboratories on this earth, but also the different spectra and positions of the dark lines or bright ones, &c., obtained from the various orders of celestial

objects, such as the sun and stars, comets, nebulae, planets, and so on; we must for this purpose have something attached to the telescope. Fig. 16 shows a star spectroscope, which differs in arrangement only and not in principle from other spectroscopes, except in one point to which I have to draw attention with regard to this spectroscope. I have insisted on the importance of the slit; but you will see in a moment that the image of a star, if it is a good image, will be a mere point in the telescope, and therefore, while

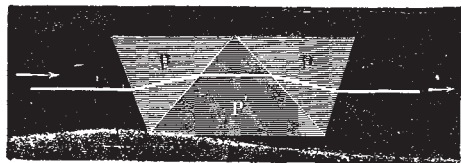


FIG. 17.—Direct-vision prism with three prisms.

a slit is not absolutely necessary, it is essential to have some arrangement by which that point of light, the spectrum of which would be merely a line, and therefore not broad enough to enable us to see what the lines are which we may expect in the spectra of stars, if they be anything like the spectrum of the sun, shall be turned into a band. That has been accomplished by means of a

cylindrical lens, its function being to leave the light alone in one direction, but to turn it into a band in another direction, so that when the light of the star gets through such a lens, it is no longer a point but a line, and this is then grasped by the collimating lens, sent through the prisms, and received by the observing telescope, so that when you get the image of it in the observing telescope, instead of having a line of light so fine that the lines in it cannot be distinguished, it is a distinctly broad band in which the lines can be observed. As this lens is simply a contrivance for enabling the eye to see about where there is a line, I submit now, as I submitted some years ago, that a proper place for it is close to the eye, between the eye and the image. I have been gratified to find that, in many of the spectroscopes used on the Continent, this arrangement is adopted.

We have now an idea of the action of the simple prism. I will next bring to your notice another kind of prism, which differs from the simple one very much as the achromatic telescope differs from the non-achromatic one, which was the first attempt made at an instrument for astronomical observations. Many of you know that the object-glass of a telescope, as now constructed, consists of two lenses made of different kinds of glass. Of course, we have dispersion and deviation at work in both these kinds of glass, but the lenses are so arranged, and their curves are so chosen, that, as a total result, the deviation is kept while the dispersion is eliminated, so that, in the telescope, we have a nearly white image of anything which

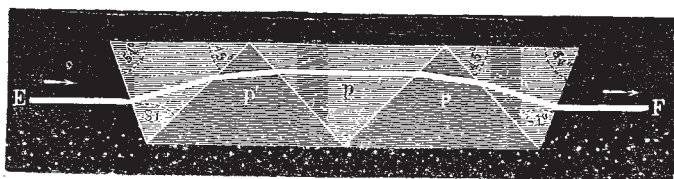


FIG. 18.—Direct-vision prism with five prisms.

gives us ordinary light, although, as you know, it is by the deviation alone that we are enabled to get the magnified image of that object. So also in the spectroscope we have an opportunity of varying the deviation and the dispersion. By a converse arrangement we can keep the dispersion while we lose the deviation; in other words, we have what is called a direct-vision spectroscope. If we take one composed of two prisms of one kind of glass which possesses a considerable refractive power, and three prisms of another kind which does not refract so strongly, arranged with their bases the opposite way, the deviation caused by the two prisms in the one direction will be neutralised by the deviation of the three prisms in the opposite direction; whilst the dispersion by the three prisms, exceeds that which is caused by the two prisms in the opposite direction, the latter dispersion therefore will neutralise a portion only of the dispersion due to the three prisms. The final result is that there is an outstanding dispersion after the deviation has been neutralised, so that when we want to examine the spectrum of an object we no longer have to look at it at an angle. No doubt you recollect the angle that was made by the light the moment it left the prism, but we have an opportunity, by this arrangement, of seeing the spectrum of an object by looking straight at the source of light; in the application of spectrum analysis, especially to the microscope and telescope, this modification—due to M. Janssen, the well-known astronomer, who was the first to bring it into general notice—is one of great practical importance, so that in any research which does not require excessive dispersion,

this direct-vision arrangement is getting into common use. I have here another direct-vision arrangement which is well worthy of being brought to your notice. It does not depend at all upon the principles I have just been trying to explain to you. It is called the Herschel-Browning direct-vision spectroscope, in which the ray is refracted and reflected internally, in the prisms themselves. We have therefore, in addition to the simple prism which I formerly brought to your attention, two other aids to research of extreme value in certain classes of observations. The direct-vision spectroscopes which are now sold are made on one of the two principles just described; some of them are made so small that they can be easily carried in the waistcoat-pocket, and still are so powerful that all the principal, and many of the less prominent, lines in the solar spectrum may be seen with them.

Of the special application of the spectroscope to the microscope I need say but little now. The spectroscope thus used is a direct-vision one, this form being far more convenient for attaching to the microscope. The light which illuminated the object in the microscope was first of all passed through a prism; but in later arrangements it passes through the prism in its passage from the object. This is obviously a much better plan, because, in the first instance, you could only deal with transparent objects; but here, as you deal in any case with the light that comes from the object itself, it is quite immaterial whether the object be opaque or transparent.

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(To be continued.)